RESEARCHES ON DESIGNING AND FUNCTIONING AN INNOVATIVE MODEL OF VERTICAL HEAT RECOVERY DRYING FOR AGRICULTURAL SEEDS

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Abstract

The drying process is affected both by the complex thermo physical processes (diffusion, thermal diffusion etc.) that take place inside the particles forming the product which is dehydrated and by the mass and heat transfer in the boundary layer that separates the surface of the solid body from the thermodynamic agent, also called drying agent. In order to study the drying process of the agricultural seeds and to optimize the parameters of the dehydration process a innovation vertical drier with heat recovery was designed and built. The drier allows the surveillance of the parameters involved in the drying process of the agricultural seeds. The following parameters are continuously measured and recorded: ambient air temperature and humidity, the temperature and humidity of the drying agent, the temperature and humidity of the seeds, the energy consumed. The drier is equipped with a frequency converter which allows the continuous adjustment of the velocity of the drying agent and with a data acquisition card (DAQ) to secure the transfer of data to a PC.

Key words: drying, vertical drier, agricultural seeds

Drying operation based technology is reducing the water content, respectively substance soluble concentation growth to levels that stabilize agricultural seeds storage.

Removing water from seeds should be directed so that hydrophilic colloids to maintain rehydration capacity. If seeds, drying natural moisture content is reduced to alevel that would prevent activity of microorganisms without tissue damage or to depreciate the value of their food.

The mechanism for drying process it is determined by some complex thermophysical processes occurring inside the particles undergo dehydration product (diffusion termodiffusion) and simultaneous mass and heat transfer in the boundary layer separating the seeds surface thermodynamic agent, which is called drying agent (hot air, flue gas or a mixture of gas and air etc).

This determines that the work is complex and dynamic drying time. (Dieter B., Karl S., 2006; Incopera D. et. al., 2007).

MATERIAL AND METHOD

Innovation vertical drier with heat recovery (*figure 1*) for drying various cereals is based on heat transfer by convection.

The dryer is made of a metallic casing having five cylindrical sections made of perforated sheet metal and two conical end sections. The cylindrical sections consist of two concentric cylinders of different diameters which make the seed drying chamber. The vertical drier is provided at the bottom outside with an air heater battery (electrical resistors) and a centrifugal fan. At the top of the vertical drier is a air lock, a seed separator and a fan that provides the pneumatic seeds transport.

The vertical drier has temperature and humidity sensors for air, drying agent and agricultural seeds. All sensors are connected to a data acquisition card that connects to a PC and monitors the drying parameters (Cârlescu P., 2017).

Moisture and temperature sensors for air, drying agent and seeds are wireless. The connection between the computer and the sensors is made by the wireless device.

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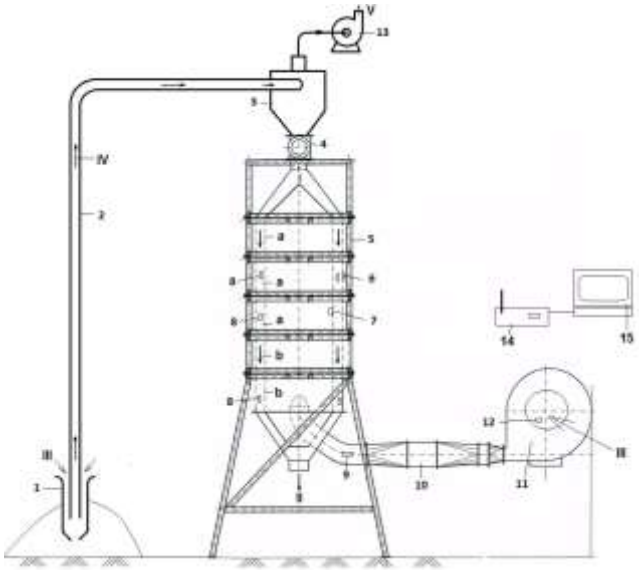

Figure 1 **Innovation vertical drier with heat recovery**

1– seed feed device; 2– pipe; 3– seed-air separator, 4– air lock, 5– vertical drier, 6– wireless sensor agent used; 7– wireless sensor agent; 8– temperature sensor inside the dryer; 9–velocity sensor; 10– air heater battery, 11– fan; 12–wireless sensor; 13– pneumatic fan; 14– wireless device; 14– PC; I– wet seeds; II– dried seeds; III– air; IV– mixed air seeds; V- air; a– drying section; b– cooling section.

Adjusting the speed of the drying agent in the vertical drier is achieved by varying the fan speed of the fan motor by means of a frequency converter. Constant maintenance of the temperature of the heating agent at the outlet of the heating battery is achieved by means of a thermostat. The installation is equipped with electronic counters for continuous monitoring in electronic format of the energy consumption.

RESULTS AND DISCUSSIONS

Innovation vertical drier with heat recovery is a complex installation that can optimize workflow parameters, namely: drying temperature, drying time, drying speed, etc. for various agricultural seeds.

Registration experimental data can be transferred to external PC very convenient with wireless technology, including the development graphics respect to temperature and humidity inlet and outlet drying agent (*figure 2*). Each wireless sensor in the drying system displays on a PC a specific graph that simultaneously monitors the temperature and humidity parameters for air, drying agent, used drying agent and seeds to be dried. The parameters and working range are shown in (*table 1).*

Vertical drier achieved can be used for both dry grain and malt or other granular products.

If the initial grain moisture at harvest depends on weather conditions and harvesting. Such moisture can be 11 to 14% for cereals harvested when fully ripe and dry weather, and in case of harvesting during rainy humidity can reach 18 to 22%. To ensure conservation conditions, grain moisture should be below 14 to 15%.

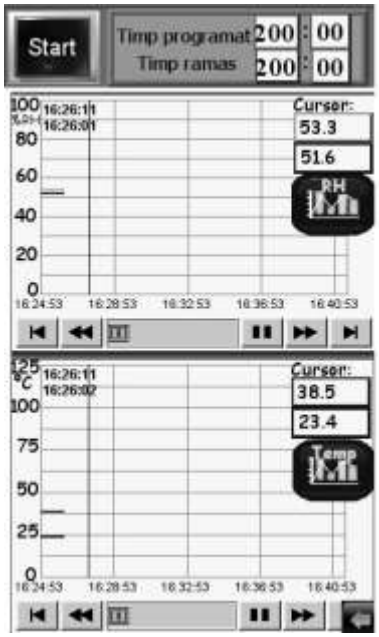

Figure 2 **Monitoring workflow parameters with PC**

By introducing the agricultural seeds into the drying chamber of the dryer at its top, the drying agent horizontally crosses the seed layer taking up the moisture it eliminates in the atmosphere outside the dryer. To extend the drying time, the seeds move in the dryer after a helical trajectory from the top down.

After the convective drying of the seeds, they are cooled in the lower sections of the dryer. Dried and cooled seeds are discharged to the bottom of the drier.

The drying process of the agricultural seeds in the vertical drier takes place in three phases, namely preheating the seeds in the first section, drying them in the next two sections and cooling them in the fourth and fifth sections.

Observing the three phases and uniformly distributing the temperature of the drying agent in the seed bed makes the drying good.

Reducing energy consumption in the process of convective drying of seeds is achieved by recovering heat in the lower sections where seed cooling takes place. The hot air from the dried seeds is mixed with the heated drying agent with the heating battery and is evenly distributed in the seed layer in the upper drying regions.

Table 1

Monitoring workflow parameters

Parameter	Working range	Observations
Air velocity (m/s)	0.5 – 3	Set by speed electric motor.
Air inlet temperature (°C)	0 – 50	Ambient temperature.
Inlet air humidity (%RH)	0 – 100	External humidity environment.
Air temperature during drying (°C)	20 – 90	Temperature of the air entering the vertical drying.
Air humidity out of the dryer (%RH)	0 – 100	Humidity coming out of the dryer.
Seeds temperature (°C)	20 –75	Temperature of the seeds depends on the agent temperature.
Load energy factor (%)	0 – 100	Depending on fan speed and temperature of the drying.

The vertical drier can operate continuously or discontinuously as required and the amount of seed to be dried. The total drying time is based on the initial moisture content of the agricultural seeds.

During drying occur simultaneously two distinct processes, namely an internal diffusion and external diffusion. Drying is all these two basic processes and speed the drying time of the slowest speed of elementary processes. In the process of seed heating, the water diffuses inside the seeds from the inside to the outside. The heating time depends on the thickness of the grain layer. Cereal drying occurs by mass transfer into the boundary layer at the surface of the solid particles when the high temperature and low humidity drying agent picks up this moisture and dissipates it to the outside of the dryer. By taking the moisture from the drying agent, its temperature drops to a few degrees becoming a drying agent. When cereal seeds reach near moisture conservation time and energy consumption for drying grow. In this final stage, cooling takes place in order to bring the agricultural seeds to the ambient temperature and to avoid condensation of the water vapor on the solid surface of the seeds. For proper drying and low energy consumption the gradient of temperature and humidity inside the seed layer should be as uniform as possible.

Also, finding the optimal drying temperature depending on seed moisture is important in the drying process. Continuous control and monitoring of temperature and humidity parameters is the key to obtaining a dry quality product.

Diagram convective drying kinetics show that variation in time of drying parameters. The analysis of the two graphs in (*figure 3*) shows that the breast drying three distinct phases:

- The time heating of cereals, where speed of drying is an increasing trend;
- constant rate drying period;
- decreasing speed drying time.

The temperature and humidity of grain seeds subjected to the drying process are monitored continuously by the sensors positioned in the grain layer on each section.

Processes monitoring important parameters in the drying process are identical to those of the dry grain.

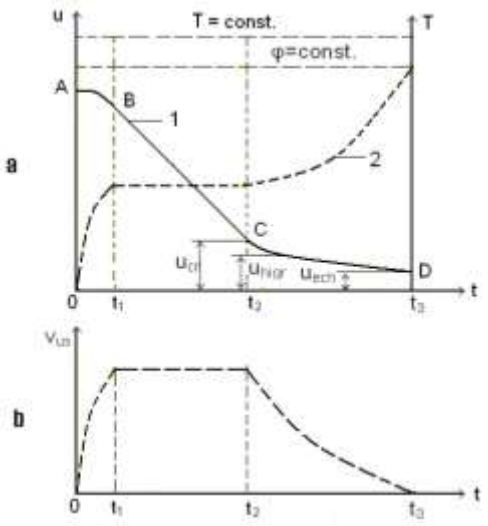

Figure 3 **Variation of kinetic parameters defining the convective drying process**:

a - temperature and humidity chart: *1* – humidity curve; *2* – changes in product temperature.
b - variation speed drying.

At the end of the drying process, the monitored parameters (humidity, temperature, power consumption) are transferred in numerical form, presented in graphical form and saved on a PC.

CONCLUSIONS

Innovation vertical drier with heat recovery is a complex installation, which can optimize workflow parameters, namely: drying temperature, drying time, drying speed, etc.

Vertical drier can be used for drying various granular products (grains, malt, etc.).

Registration experimental data can be transferred to external PC, including graphs of temperature and humidity evolution drying agent (input and output).

ACKNOWLEGMENTS

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